Big Bar Project
Soils and Watershed Input

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Soil and Watershed Actions

There is a need to improve roads to reduce the amount of sediment from roads that reach streams. To protect water quality, roads will be modified by adding drainage structures such as critical dips, rolling dips, dips with leadoff ditches, and ditch relief culverts, and by out-sloping certain segments of road. Other activities include rocking inside ditches and rocking segments of road. Below are identified road work that will improve water quality.

- 23N00
    - Construct 3 rolling dips, 5 critical dips, and regular road maintenance.
- 23N28
    - Construct an over side drain and armor fill, 4 rolling dips, and armor an inside ditch.
- 23N58X
    - Construct a rolling dip and improve water drafting site.
- 22N71X
    - Construct an armored low water crossing and a rolling dip.

General road maintenance includes cleaning inside ditch, cleaning ditch relieve culverts, blading road surface, and cleaning the inlets and outlets of stream crossings.

Subsoiling should be prioritized on soil units SY04, SY07, SY08, and any other areas that show evidence of significant compaction. The last 200 feet of existing and new skid trials leading to the landings will be subsoiled. Any new temporary roads the entire length will be subsoiled as well. All existing and new landings will be subsoiled too.

Restrictions/Design Features

- All skid trails and temporary roads will have waterbars as erosion control features.
- Adhere to FS-990a National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide (April 2012), in particular:
    - Mechanical Vegetation Management Activities: Veg 1-4 (especially Veg -3, Aquatic Management Zones), 6, and 8; pgs. 128-140.
- Adhere to R5 FSH 2509.22 Soil and Water Conservation Handbook, Chapter 10 Water Quality Management Handbook, Amendment # 2509.22-2011-1 (Dec 05, 2011). In particular, BMPs 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14, 1.15, 1.16, 1.17, 1.19, 1.20, 1.21, 2.2, 2.3, 2.4, 2.5, 2.6, 2.8, 2.11, 5.1, 5.2, 5.4, and 5.6.
- More design specific design features are located in project appendix that contains all the resources' design features/mitigations. Below are some of the most crucial for soils and watershed.
    - See Table 1 for the RCA Heavy Equipment Exclusion Zone
    - Limiting Operating Period (LOP) (BMP 1-5, BMP 1-13) for soil moisture.
        - Conduct ground based harvest operations when soil is dry; that is, in the spring when soil moisture in the upper 8 inches is not sufficient to allow a

soil sample to be squeezed and hold its shape, or will crumble when the hand is tapped. In the summer and early fall after storm event(s) when soil moisture between 2-8 inches in depth is not sufficient to allow a soil sample to be squeezed and hold its shape, or will crumble when the hand is tapped. Work on streams should occur during low flow (late summer)

- If effective soil cover is below the desired level of soil cover along streams then leave slash material to increase soil cover. When cutting trees lop and scatter broken tops and limbs within 1 tree length of any stream.
- Fuel outside of riparian areas. 300 feet on perennial and 150 feet on seasonal flowing streams.
  - BMP 2.11 (Equipment Refueling and Servicing) will prevent fuels, lubricants, cleaners, and other harmful materials from discharging into nearby surface waters or infiltrating through soils to contaminate groundwater resources.

Table 1. RCA Heavy Equipment Exclusion Zone Widths and Slope Restrictions

Stream Type	Equipment Exclusion Zone (EEZ) for Mechanical Thinning via Salvage, Roadside Hazard Tree Removal, and Grapple Pile		Mastication	Underburn[1]	Hand Cut[2]	Minimum Distance to Burn Piles
	Slope <35%	Slope >35%				
Perennial streams	100 feet	Excluded	50 feet	150 feet	No buffer	25 feet
Intermittent streams	100 feet	Excluded	50 feet	150 feet	No buffer	25 feet
Ephemeral streams	25 feet	Excluded	25 feet	150 feet	No buffer	25 feet
Special Aquatic Features (Reservoirs, wetlands, fens, and springs)	50 feet	Excluded	50 feet	150 feet	Perimeter	25 feet
Riparian Features: dry meadows, seasonal wetlands	0 to 25[3]feet	Excluded	25 feet	150 feet	Perimeter	25 feet

1. Prescribed burning would be allowed within RCAs, but there would be no ignitions in riparian vegetation. Fire may back through this zone.
2.May hand cut within RCA feature but don't cut riparian vegetation. Don't cut vegetation that provides stream bank stabilization. Adhere to the minimum distance for burn piles. No hand cutting within special aquatic features and riparian features unless marked by hydrologist and/or biologist.
3. Meadows may have no buffer to a 25 ft. buffer depending on the individual meadow. Buffers may vary due to the condition of the meadow (i.e. meadow is encroached with trees).

Hydrology Analysis

Protection of water quality and quantity is an important part of the Forest Service's mission (USDA Forest Service 2007). Management activities on national forest lands must be planned and implemented to protect the hydrologic functions of forest watersheds, including the volume, timing, and quality of streamflow. The Clean Water Act of 1948 (as amended in 1972 and 1987) establishes as federal policy the control of point and non-point source pollution and assigns to the States primary responsibility over control of water pollution. The Forest Service is required to protect and enhance existing and potential beneficial uses during water quality planning (California Regional Water Quality Control Board

[CRWQCB], 1998). Compliance with the Clean Water Act by national forests in California is achieved under state law (see below). Beneficial uses are defined under California State law in order to protect against degradation of water resources and to meet state water quality objectives. The 1988 Plumas National Forest Land and Resource Management Plan states: "maintain or, where necessary, improve water quality using Best Management Practices (BMPs)." BMPs are procedures, techniques, and mitigation measures that are incorporated in all Plumas National Forest actions to protect water resources and prevent or diminish adverse effects to water quality. Subsequent Forest Plan standards and guides state: "implement BMPs to meet water quality objectives and improve the quality of surface water on the Forest."

Direct and Indirect Effects of Non-Chemical Treatments

The primary treatment is to salvage trees in those areas affected by the 2018 Camp Fire via mechanical thinning. A direct effect of the proposed action is that effective soil cover will be increased as a result of design features such as the broken tops and limbs of the felled trees will be left in place within tree length of any stream. Increasing the effective soil cover is an improvement over the existing condition where little effective soil cover is present to effectively stop erosion. The amount of increased soil cover is hard to predict and there is a probability that some units won't be able be able to achieve a minimum percent effective soil cover but still that would be an improvement. An indirect effect of implementing the project is that erosion and the amount of sediment entering Lake Oroville will be qualitatively lower. The design features and BMPs are intended to project the water quality while moving forward with the projects intent to salvage and remove hazardous trees. One example is that having a LOP on soil moisture and limiting the number of passes a rubber-tired skidder has over the same piece of ground in RCAs will help reduce the possibility of channelized flow while still increasing effective soil cover by leaving the broken tops and limbs. The implementation of the project is not expected to cause any direct and indirect significant negative effects to the waters of Lake Oroville.

Other planned activities besides the initial salvage are site prep for planting and maintenance of the landscape for fuels. The site prep treatments include grapple pile, planting and grubbing after planting. The site prep treatments should not cause any direct and indirect effects to the projects waters and its beneficial uses. BMPs and design features will be in place to project water quality which are in the mitigation table of the project.

The maintenance for fuels reduction can include mastication, hand cut pile burn, grapple pile, grazing and underburn. These treatments will not have direct and indirect effects to water quality as long they adhere to RCA buffers (Table 1), BMPs, and design features.

Road surveys found some hydrologic issues on Forest Service system roads. The roads that were assessed with issues were 23N00, 23N28, 23N58X, and 22N71X.

Table 2 shows the type of road improvements expected to occur to improve water quality. Rolling dips are identified fix road segments that are depositing sediment into a stream by disconnecting the surface runoff away from the channel. Critical dips are constructed just below/adjacent to stream crossing where the streams if overtopped would remain in their original drainage instead of going down the road and potentially enter another stream. Armoring inside diches are intended to reduce the velocity and erosion potential of the runoff that enter streams. The construction of a low water crossing on 22N71X will ensure that the stream flow is not diverted down the road as it currently is. The construction of the fore mentioned features will be done when the streams are not flowing or when flows are minimal. In addition, BMPs and design features will be in place to minimize impacts to water quality. Long-term water quality and its beneficial uses would be improved because the issues identified got fixed.

Table 2. Road Worklist for Improving Water Quality

Road ID	Road Improvement Worklist
23N00	Construct 3 rolling dips, 5 critical dips, and the regular road maintenance.
23N28	Construct an over side drain and armor fill, 4 rolling dips, and armor an inside ditch.
23N58X	Construct a rolling dip and improve water drafting site.
22N71X	Construct an armored low water crossing and a rolling dip.

Cumulative Effects of Non-Chemical Treatments

The Cumulative Watershed Effects (CWE) analysis is based on the guidance from the Forest Service Handbook FSH 2509.22-Soil and Water Conservation, Region 5 Amendment (USDA Forest Service 1988c). Effects may be either beneficial or adverse and are a result of combined effects of multiple management activities within a watershed. Beneficial uses for waters in the project are identified below the RCO analysis. Alterations to watershed hydrology are believed to be the most probable mechanism for initiating these effects to aquatic habitat (USDA Forest Service 1988c). The Region 5 Forest Service Handbook amendment utilizes conceptual site disturbance coefficients called equivalent roaded acres (ERA) to track changes in the hydrologic functioning of watersheds. ERA coefficients are used to compare the effect of management activities (e.g. timber harvest or pile burning) to the effect of a road in terms of altering surface runoff patterns and timing. The sum of these coefficients represents the percentage of watershed in road surface that would produce the same effects as the existing or planned distribution of management activities (Berg et al, 1996).

Watersheds and stream channels have a natural capacity to absorb various levels of land disturbance without major adjustment to their function and condition. However, there is point where additive or synergistic effects of land use activities would cause a watershed to become highly susceptible to cumulative effects. This upper estimate of watershed “tolerance” to land use is described as the threshold of concern (TOC). When the sum of disturbances exceeds the TOC, water quality may be impaired for established beneficial uses, such as aquatic habitat. Stream channels and water quality can deteriorate to the point where adjacent riparian areas and wetlands become severely damaged.

Project level TOCs are estimated by considering the sensitivity of each analyzed watershed. Natural watershed sensitivity is an estimate of a watershed’s ability to absorb land use impacts without increasing the effects of cumulative impacts to unacceptably high levels (USDA Forest Service 1988c). For this project, the TOC has been conservatively set at 16 percent across all project specific watersheds. The ERA total of each watershed, expressed as a percentage of the watershed area, is compared to the TOC and reported as a fraction (percent) of the TOC. ERA totals in the range of 90 to 99 percent of TOC are considered to be approaching TOC, while those that are 100 percent or greater equal or exceed the TOC. The TOC does not represent an exact level of disturbance where cumulative watershed effects will begin to occur. Rather, it serves as an indicator of increased risk of significant adverse cumulative effects occurring within a watershed. If a watershed is approaching or above the TOC, a more thorough analysis of the activities planned within the watershed is necessary.

For the proposed activities, the ERA model analyzed for what conditions would be like upon completion of the project. It adds the effects of the proposed activities onto the existing condition. The model's assumption is that all the proposed activities would occur within one year but, that doesn't occur all the time. The model looks at worst a case scenario that is used to identify watersheds that may need a closer look at cumulative watershed effects that may have a negative or adverse effect to beneficial uses. The implementation of proposed activities may take up to 10 years due to various factors. One factor is funding, for example the Forest Service may have limited funding to cruise and layout units in any given year. Service work (mastication, hand cut pile burn, underburn) at times is dependent on Knutson Vandenberg (KV) funding, grants, and Forest Service funds. Another factor is that the purchaser of timber contract determines when they work and complete the treatments. The market influences the contract purchaser actions too. Weather and politics determine when prescribed pile burning and underburning occur.

Elven watersheds were delineated for the project and under the existing condition none of them are at or over TOC. The range of percent TOC is from 7 to 79 percent for the existing condition as identified in Table 3. If the first phase (salvage trees) of the Big Bar Project gets implemented this year (2019) then none of the watersheds will be at or over TOC. The closet watershed to be approaching TOC is watershed 8 at 82 percent TOC. The biggest increases in percent TOC if the project gets implemented would occur in watersheds 5 and 6 at 24 percent and 32 percent. Based on the ERA modeling of the proposed action, no watershed will be at or over TOC. BMPs and design features will be in place to ensure that surface runoff patterns and timing are not altered to significantly impact water quality or affect beneficial uses of water.

Table 3. Percent TOC by Watershed

Watershed Number	Area (acres)	Percent TOC		
		Existing Condition	Big Bar Proposed Action	Percent Increase in TOC Due to Proposed Action
1	1,957	22%	22%	0%
2	1,163	12%	12%	0%
3	1,823	7%	9%	2%
4	1,545	23%	30%	6%
5	968	48%	72%	24%
6	1,106	45%	77%	32%
7	1,872	46%	48%	2%
8	2,056	79%	82%	4%
9	1,048	65%	66%	1%

Watershed Number	Area (acres)	Percent TOC		
		Existing Condition	Big Bar Proposed Action	Percent Increase in TOC Due to Proposed Action
10	1,916	70%	71%	2%
11	1,976	55%	60%	5%

Direct and Indirect Effects of Chemical Treatments

Currently no invasive plants were found within the project area. However, the potential exists that some of them might establish themselves. If invasive plants are found, then herbicides may be applied to stop the spread and eventually eliminate them. The possible routes by which herbicides may contaminate water would be direct application, drift into streams from spraying, runoff form large rain event soon after application, and leaching through the soil into ground water or into a stream. This section addresses each of these delivery routes. No direct application of herbicide to water is proposed for this project. General characteristics for the proposed herbicides are displayed in Table 4. These were compiled from the label information and SERA Risk Assessments.

Table 4. Herbicide Behavior in Soils and Water.

Chemical	Environmental Fate and Hazards	Leaching Potential	Runoff Potential	Soil Half-life (days)
Aminocyclopyrachlor	Degrades primarily via photolysis. Low binding strength to soils.	High	High	114-433
Aminopyralid	Degrades rapidly in water. Relatively stable in soils. Non-toxic to soil microorganisms.	Low	Low	20-32
Chlorsulfuron	Mobile in soil and may leach and contaminate groundwater. Degrades rapidly in water.	High	Low	40
Clopyralid	Does not bind strongly to soils and has the potential to be highly mobile in soils especially sandy soils. Degrades primarily by microbial activity in soil and it's relatively rapid. Dry conditions are preferred for effective treatment.	High	Low	20-40
Fluazifop-P-butyl	Degrades rapidly in water and moist soils. Non-toxic to soil microorganisms. Dry conditions are preferred for effective treatment.	Low	Low	21
Glyphosate	Adsorbs tightly to soils. Subject to rapid microbial degradation. Non-toxic to soil microorganisms. Low drift potential.	Low	Low	47
Imazapyr	Moderately persists in soils and has a low degradation. Slight potential for longer-term effects on soil microorganisms at high application rates	Low	Low	25-145
Triclopyr	Weakly bound to soils. Potential for off-site movement through drift, runoff, and wind erosion. Relatively non-toxic to soil organisms.	Low	Moderate	46

Even though there are no known invasive plant sites within the project area pesticide no-spray buffers will be in place. The buffers in Table 5 are for the most part greater than what has been done on other projects on the Plumas National Forest. These buffers are more restrict because it's a fire salvage project and will adhere to the Water Discharge Requirements General Order R5-2017-0061 (herein referred to as General Order) set by the California Regional Water Quality Control Board for the Central Valley Region.

Table 5. Stream and Aquatic Features Buffer Widths for Herbicide Application

Herbicide Active Ingredient	**Live Water** (Perennial streams, lakes, ponds, springs, fens, bogs)		**No Live Water** (Seasonal wetlands when dry; seasonally flowing / intermittent channels that support a continual strip of riparian vegetation)		**Ephemeral Streams** (Dry washes without riparian vegetation)	
	Percent Slope					
	<30	**30-50**	**<30**	**30-50**	**<30**	**30-50**
Aminocyclopyrachlor	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Aminopyralid	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Chlorsulfuron	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Clopyralid	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Fluazifop-P-butyl	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Glyphosate	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Imazapyr	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Triclopyr-TEA	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Triclopyr-BEE	75 ft.	100 ft.	50 ft.	75 ft.	25 ft.	50 ft. with a min. of 50% effective soil cover
Buffer distances are measured from the water's edge. Roadside ditches will be treated the same as the water body type they resemble						

The eight herbicides would be used with adjuvants such as surfactants which break up the surface tension of the herbicide and increase the ability for plants to absorb the herbicide. Since any surfactants used would be mixed as a small percentage of an herbicide, the effects on the environment, including soils and water quality would the same as the herbicide (Bakke 2007). Dyes would be used in the herbicide application to identify areas treated and reduce the chance of misdirection spray. Dyes or similar biodegradable colorant to facilitate visual control are water soluble dye and contains no listed hazardous chemicals. They are considered virtually non-toxic to humans (Bakke 2007). For the remainder of this analysis, the discussion of effects resulting from herbicide application takes into consideration the effects of herbicides active and inert ingredients, metabolites, surfactant, and marker dye.

Aminocyclopyrachlor is a persistent compound that will degrade primarily via photolysis post application. It slowly degrades by aerobic microbial metabolism with half-lives ranging from 114-433 days in soils and 29-168 days in water. It is stable to degradation via other pathways. Aminocyclopyrachlor is also expected to be highly mobile in the environment. This product may impact surface water quality due to runoff of rainwater. This is especially true for poorly draining soils and soils with shallow ground water. However, the project site has soils that drain well so runoff potential is lower. This product is classified as having high potential for reaching surface water via runoff for several months after application. DF-8 listed in Table 6 is limits the application of aminocyclopyrachlor to late spring and early summer to maximize the days for the chemicals to degrade as well as minimize leaching and runoff potential. Runoff of this product will be reduced by avoiding applications when rainfall is forecasted to occur within 48 hours.

Table 6. Herbicide Application Design Features

Design Feature	Soil and Water Design Standards	Purpose of Design Standard	Source of Design Standard
DF-1	Areas with bare soil created by the treatment of noxious weeds would be evaluated for rehabilitation (i.e. reseeding, mulching, etc.)	To ensure that the treatment of noxious weeds is not creating open areas or bare areas for spread of noxious weeds and to protect water quality and riparian habitat.	BMP 5.4: Revegetation of Surface-disturbed Areas (R5-FSHB 2509.22)
DF-2	**Areas outside of ephemeral stream**: If treatment reduces soil cover to less than 50% for a contiguous are of >0.25 acres, then mulching and/or revegetation may be required to minimize erosion and reestablish native vegetation. Only native plant species will be used in revegetation. All mulch and seed material will be certified weed-free. **Areas within 50 feet of ephemeral stream**: If treatment reduces soil cover to less than 70% for a contiguous area of >0.1 acres, then mulching and/or revegetation may be required to minimize erosion and reestablish native vegetation. Only native plant species will be used in revegetation. All mulch and seed material will be certified weed-free.	To ensure that the treatment of noxious weeds is not creating open areas or bare areas for spread of noxious weeds and to protect water quality and riparian habitat.	BMP 5.4: Revegetation of Surface-disturbed Areas (R5-FSHB 2509.22)
DF-3	Herbicide mixing will not occur within 150 feet of the ephemeral stream and inside ditch. The cleaning and disposal of herbicide containers will be done in accordance with Federal, State, and local laws, regulations, and directives.	To reduce risk of contamination of water by accidental spill.	BMP 5.10: Pesticide Soil Contingency Planning (R5-FSHB 2509.22) BMP 5.11: Cleaning and Disposal of Pesticide Containers and Equipment (R5-FSHB 2509.22) National BMP Chem-5: Chemical Handling and Disposal (FS-990a)
DF-4	When applying herbicides with a backpack sprayer all directed spray will be done in a downward direction in accordance to the herbicide's label. This will minimize herbicide drift and confine the herbicide to the drop zone of the individual weed plant being treated.	To control drift within the entire project area especially within sensitive areas and near water.	BMP 5.12: Streamside Wet area Protection during Pesticide Spraying (R5-FSHB 2509.22) BMP 5-13: Controlling Pesticide Drift During Spray Application (R5-FSHB 2509.22) National BMP Chem-1: Chemical Use Planning (FS-990a)
DF-5	All herbicide application will follow EPA approved label directions in regards to control of drift of herbicides during spraying. These directions have specific wind speeds and air temperatures for application of each herbicide. Applicators will utilize droplet size and spray pressure to insure droplets do not travel outside of the drip line target plant. A colorant would	To control drift of herbicides onto unintended targets and to minimize risk of surface water contamination.	BMP 5.8: Pesticide Application According to Label Directions and Applicable Legal Requirements (FSHB 2509.22) BMP 5.9: Pesticide Application Monitoring and

Design Feature	Soil and Water Design Standards	Purpose of Design Standard	Source of Design Standard
	be added to the herbicide mixture prior to spraying. Spray cards may be used to aid in detecting herbicide drift.		Evaluation (R5-FSHB 2509.22) BMP 5.13: Controlling Pesticide Drift during Spray Application (R5-FSHB 2509.22) National BMP Chem-2: Chemical Use Planning (FS-990a)
DF-6	POEA surfactants will not be used within 150 feet of live waters.	To protect aquatic organisms.	BMP 5.12: Streamside Wet area Protection during Pesticide Spraying (R5-FSHB 2509.22)
DF-7	Roadside ditches will be treated the same as the water body type they resemble.	To project water quality and meet SNFPA Riparian Management Objectives. Also to ensure that TECS and Special Interest plants are protected.	BMP 5.12: Streamside Wet area Protection during Pesticide Spraying (R5-FSHB 2509.22)
DF-8	Application of Aminocyclopyrachlor, and Imazapyr will be limited to late spring and early summer. No application of these chemicals after that timeframe.	To project water quality.	National BMP Chem-1: Chemical Use Planning (FS-990a)
DF-9	Application Chlorsulfuron and Clopyralid will not be allowed in the fall.	To protect water quality.	National BMP Chem-1: Chemical Use Planning (FS-990a)

Chlorsulfuron and clopyralid are both considered to have a high potential for leaching. Both chemicals are mobile in soils in particular clopyralid is especially mobile in sandy soils which the project does have. Both chemicals have a range up to 40 days for their half-life in soils plus considering the high leaching potential DF-9 was developed to restrict that application of these chemicals in the fall. The purpose of this design feature to protect water quality.

Imazapyr moderately persists in soils and has a low degradation. Slight potential for longer-term effects on soil microorganisms at high application rates. Due to long soil half-life of imazapyr the application of the chemical will be restricted to only the late spring and early summer in order to maximize the number of days for the chemical to degrade. DF-8 listed in Table 6 will apply to imazapyr.

The rest of the herbicides are described briefly in Table 4. All the proposed herbicides have low runoff potential except for Aminocyclopyrachlor and Triclopyr. The design features listed in Table 6 were designed to account for herbicides active chemical varying properties and minimize its potential affect to water quality. For example, DF-8 and DF-9 were designed to give specific timeframes in which the chemicals can be applied. BMPs will be incorporated into the project to protect water quality. BMP 5.10 requires a spill contingency plan consisting of predetermined actions to be taken in the event of a spill. Water contamination resulting from cleaning or disposal of pesticide containers would be prevented (BMP 5.11). Lastly, BMP 5.13 minimizes the risk of pesticide falling directly into water, or non-target areas from drifting during spray application.

These BMPs and DFs would effectively diminish the possibility of off-site transport via runoff and limit herbicides from entering surface waters through overland flow. Therefore, the proposed treatments with chemicals and its metabolites are not expected to accumulate or negatively affect water quality in the project area or downstream.

Water Quality Monitoring Studies

The results of fifteen separate water monitoring reports written by hydrologists and geologists on Region 5 forests were summarized in a paper entitled "A Review and Assessment of the Results of Water Monitoring for Herbicide Residues For The Years 1991 to 1999" (Bakke 2001). These reports documented the results of over 800 surface- and ground-water samples taken for reforestation and invasive plant treatment projects that used three herbicides (glyphosate, hexazinone, and triclopyr).

Glyphosate was used on four Forest on eight projects and monitoring samples were collected from 1991-2000. All the projects had various buffers, one projects buffer was as small as 10 feet and it was found that all post-treatment water samples had non-detectable levels of Glyphosate except for one project. One project on the Angeles National Forest had one detection sample out of 13, 15 parts per billion (ppb) which below any level of concern for human health or aquatic resources (Bakke 2001). Triclopyr was used on five projects on three Forests. Where Triclopyr was used with buffers of 10 to 15 feet, there were three projects where detections occurred. The levels of detection ranged between 0.1 to 1 ppb where specified. One detection of 82 ppb was determined to be from not establishing a buffer on an ephemeral channel. The other detection was on a project with buffers of 10 feet; it had detection during winter storms of 0.63 parts per million (ppm) and 0.6-0.7 ppm. Another project with buffers of 15 feet had a single detection of 1 ppb (Bakke 2001). These detections are considered low and below toxicity levels for aquatic species. To be toxic for the rainbow trout for instance, would require a 96 hour exposure at 117ppm, not ppb. Triclopyr has been shown to have a half-life of 1.3 days in river water (Ganapathy 1997).

Cumulative Effects of Chemical Treatments

Management activities and actions on neighboring lands may contribute to the spread of invasive plants on National Forest lands, and vice versa. The exact amount herbicide being applied on other lands outside of Forest Service lands at times is hard to pin point. The 2017 record is the most current year available from the California Department of Pesticides. The data is specified by township, range, and section so the numbers reported may or may not fall within the project's watershed analysis area. The total pounds of chemical applied on private timberland and agriculture was 81.7 lbs. on 82 acres. See Table 7 for location where each chemical was applied and how much. Future spraying may not occur in the same locations and with varying amounts of chemicals used.

Table 7. Pounds of Chemical Applied and Acres Treated on Private

COMTRS: COunty, Meridian, Township, Range, Section	Chemical Name	Total Pounds of Chemical Applied	Acres Treated
04M22N05E11	Imazapyr	19.7	32
04M22N06E07	Glyphosate	62	50

Table 8 displays the application rate of each herbicide's active ingredient (lbs. /ac) by what invasive species may be treated. It's hard to predict how much of each chemical will be used at a given point because the amount of proposed chemicals. The purpose of analyzing for all these chemicals to ensure adaptive management is feasible to eradicate and/or control these invasive plants. Not all these chemicals will be applied at the same time to treat the same invasive plants. The amount and frequency of herbicide application will be at its highest within the first 2 years of invasive plant treatment. The herbicides will be applied no more than twice a year. The number of acres treated, and chemical used (lbs. /acre) will decrease over time as the invasive plants are eradicated and/or controlled.

Table 8. Pounds of Chemical Applied and Acres Treated at Project Site

Chemical	**Upper Application Rate of Active Ingredient (lbs./ac)**	**Invasive Species and Acreage**					
		Italian Thistle	*Scotch Broom*	*Skeleton Weed*	*Yellow Star-Thistle*	*Barbed Goatgrass*	*Medusahead*
		0 ac	0 ac	0 ac	0 ac	0 ac	0 ac
Aminocyclopyrachlor	0.19			X			
Aminopyralid	0.078	X		X	X		
Chlorsulfuron	0.08			X			
Clopyralid	0.2	X		X	X		
Fluazifop-P-butyl	0.1					X	X
Glyphosate	2		X				
Imazapyr	0.45					X	X
Triclopyr	1.12	X	X	X	X		

Applying herbicides at the typical and not maximum recommended rates will also limit the amount of excess residue present on site each year. The presence of soil microbes and soil temperatures are conducive to degrading herbicides which will limit the amount of accumulation. To address these uncertainties and help maintain little to no cumulative effect to the watershed analysis area and to beneficial users downstream, implementation of design features, and BMPs are essential.

Soil Analysis

The soils analysis looked at the soils hydrologic function, its ability to support plant growth and filtering-buffering function. The indicators and measures used for the analysis are listed in Table 9. The qualitative analysis will disclose the existing condition and compare that to the proposed activities. The project has identified specific BMPs and mitigations identified in the restrictions/design features section of this document and the Management Requirements Table.

Table 9. Soil Function Check List Used for Soil Affects Analysis

Soil Function	**Indicator & Measure**
Soil Hydrologic Functions	Soil Stability & Percent Effective Soil Cover
Support for Plant Growth	Surface Organic Matter & Percent Fine Organic Matter
Support for Plant Growth and Soil Hydrologic Functions	Soil Structure and Macro-porosity & Percent Compaction

Soil Function	Indicator & Measure
Filtering-Buffering Function	Qualitative Assessment

Indicator and Measure Assumptions

Percent Effective Soil Cover

- Duff and litter greater than ½ inch in depth, surface gravels greater than ¾ inch in diameter, woody debris greater than ¼ inch in diameter, and living vegetation count as effective soil cover.
- The Plumas National Forest Land and Resource Management Plan (LRMP) states soils with moderate, high and very high Erosion Hazard Ratings (EHRs) require a minimum of 50 percent, 60 percent and 70 percent effective soil cover, respectively.
- Soils that were surveyed would have their EHRs recalculated and the ones that weren't the EHRs would be set for moderate at 50 percent effective soil cover.

Percent Fine Organic Matter

- Duff and litter greater than ½ inch in depth and woody debris between ¼ to 3 inches in diameter will count as fine organic matter on top of the mineral soil.
- Desired condition for fine organic matter on top of the mineral soil is 50 percent or greater and will be rated as good.
- Fine organic matter on top of the mineral soil ranging from 30 percent to 49 percent will be rated as fair condition while anything less than 30 percent will be considered poor condition.
- Fine organic matter in areas that weren't surveyed will be rated as poor based on the results of the units that were surveyed (see Table 10).

Percent Compaction

- There is no set standard and guideline for percent compaction, but the measure will be utilized in order to get a better understanding of the soil structure, macro-porosity, and soil strength. Timber management activities treatments that involve mechanical equipment have the potential to compact the soil by changing the soil structure and soil porosity. Depending on the degree and aerial extent of compaction it can change the hydrologic function of an area (i.e. unit).
- If compaction is found to be greater than 10 percent, consider mitigating by subsoiling and/or implement other design features to reduce future compaction.

Qualitative Assessment of the Soils Filtering-Buffering Function

- Soil filtering and buffering capacity is the soils ability to protect water quality by immobilizing, degrading or detoxifying chemical compounds or excess nutrients. The qualitative assessment will look at potential changes to soil filtering and buffering capacity between existing condition and proposed action.

Existing Condition

Soil surveys for the project were conducted in June and July of 2019. Soil survey units were selected by looking at the soil types, soil burn severity, initial erosion hazard rating, and past management activities to determine were to survey. Approximately 52 percent of the project area was surveyed and is a representative sample of the conditions found throughout the project.

Table 10 below shows the results of the soil surveys for the project. Percent effective soil cover is met for 4 out of 7 units. Soil units SY01, SY07, and SY08 don't met the standard for percent effective soil cover. The average effective soil cover was found to be 49 percent. While not all the area was surveyed, they were visited, and representative photos of the units were taken. Based on survey results its assumed that the non-surveyed areas may not meet the project standard of 50 percent.

The soil surveys indicate that none of units meet the desired condition of 50 percent for fine organic matter. The highest unit was SY04 at 47 percent and the lowest was unit SY02 at 12 percent while the average was found to be 26 percent. Overall the fine organic matter of the units surveyed is poor to fair. Based on the surveys the non-surveyed units are assumed to have poor to fair fine organic matter as well.

Soil compaction for the units that were surveyed were found to be on average 8 percent compacted. The range of soil compaction is from 1 percent to 15 percent. Units SY04, SY07, and SY08 were found to be over 10 percent compacted. The compaction primarily was found on old skid trails. Its assumed areas that weren't surveyed that soil compaction is most likely below 15 percent because the representative surveys and the fact that major vegetation management activities (i.e. mechanical thinning) have not occurred since 2000.

The soils ability to filter and buffer chemical compounds or excess nutrients from degrading water quality is poor to fair. Soil surveys indicate that effective soil cover on average is below 50 percent and that fine organic matter is poor to fair. These two components are important to the soils ability to immobilizing, degrading or detoxifying chemical compounds or excess nutrients (i.e. top soil runoff). Currently no known pesticides use, or chemical spills are known within the project that would degrade water quality.

Table 10. Existing Soil Condition Measures

Soil Survey ID	Soil Texture	EHR	Desired Effective Soil Cover based on EHR	Existing Effective Soil Cover	Meets Effective Soil Cover	Existing Fine Organic Cover	Meets Desired Fine Organic Cover	Existing Compaction
SY01	Silty clay loam	Moderate	50%	48%	No	20%	No	7%
SY02	Sandy clay loam	Moderate	50%	50%	Yes	12%	No	3%
SY03	Silty clay loam	Moderate	50%	53%	Yes	37%	No	8%
SY04	Silty clay loam	High	60%	63%	Yes	47%	No	12%
SY06	Silty clay loam	Moderate	50%	63%	Yes	17%	No	1%
SY07	Silty clay loam	Moderate	50%	32%	No	25%	No	15%
SY08	Silty clay loam	High	60%	35%	No	22%	No	13%

Proposed Action

Direct, Indirect, and Cumulative Effects of Non-Chemical Treatments

The proposed project has 3 distinct phases. First is to salvage the trees as a result of the Camp Fire that went through in 2018. Second phase is to site prep the area for planting. Third phase is to keep the fuels down by maintaining the landscape through many different treatments.

The proposed salvage of the dead and hazardous trees is not going to negatively affect the effective soil cover and percent fine organic matter because of the various design features and mitigations of project. If effective soil cover is below the desired level, then leave slash material to increase soil cover along streams. When cutting trees lop and scatter broken tops and limbs within 1 tree length of any stream. The amount of slash that goes to landings will be minimized instead the material would be used for effective soil cover in order to promote soil stability. The slash placement will be prioritized on steeper slopes, areas along the riparian corridor, and skid trails. The percent increase in effective soil cover and organic matter is hard to predict but it would be an improvement from the existing condition and will help with soil stability and future soil nutrients. To minimize the amount of soil disturbance, logging systems will have to use existing landings and skid trials plus restrict the use of any heavy equipment to 35 percent. A soil moisture LOP would be in place for the use of heavy equipment which will minimize ruts and compaction therefore keep the erosion to a minimum. Subsoiling should be prioritized on units SY04, SY07, SY08, and any other areas that show evidence of significant compaction.

Site prep treatments such as grapple piling, planting and grubbing short-term will disturb the ground and may cause some erosion. However, the grapple piling and grubbing will have to adhere to the RCA buffers identified in Table 1. The project will have BMPs and design features to keep the amount of erosion to a minimum. The proposed site prep activities are not expected to change the soils hydrologic function and its ability to support plant growth.

The third phase includes various treatments such as mastication, hand cut pile burn, grapple pile, grazing, and underburn in order to maintain the fuel levels low. These treatments are less disturbing to soils across the projects landscape when compared to the salvage component of the project. Mastication is more likely to increase effective soil cover and fine organic matter because it rearranges the fuels down to the ground as copped up organic matter. Hand cut pile burn will decrease effective soil cover and fine organic matter but it will be minimal because those reductions are isolated to those piles. Grapple pile is anticipated to be the more disturbing treatment to effective soil cover and fine organic matter because it rearranges the fuels into larger piles which are eventually consumed by fire. Grazing will have design features to keep the amount of fuel consumed by goats to acceptable levels where they don’t leave soil bare to appoint were erosion becomes an issue. Underburning would occur under prescribed conditions that would not result in the complete combustion of the duff and litter layer. Instead it will burn in a mosaic pattern only consuming the fine organic matter where the fire went through. The underburning within the RCA buffers would have a mosaic pattern due to the varying moisture conditions and the impacts should be minimal and not significant to effective soil cover. The BMP effectiveness was rated as

92 percent for underburn units for 2011. The 2011 Best Management Practices Evaluation Program (BMPEP) Report found that the implementation and effectiveness of the BMPs for 2011 was at 100 percent and 97 percent, respectively (USDA Forest Service 2011b). Specific BMPs and design features will be in place to keep the soils functions working. The various treatments for maintaining the landscape are not expected to cause significant issues for the soils hydrologic function and ability to support plant growth.

Direct, Indirect, and Cumulative Effects of Chemical Treatments

To prevent the spread of Heterobasidion annosum (annosus) root disease sodium tetraborate decahydrate (a fungicide treatment) is proposed to be used. The treatment will only be applied during the first phase of the project, which is the salvage component and not the other two phases. Sodium tetraborate decahydrate, also known as borax, is the active ingredient and sole constituent in Sporax. The compound borax is not applied as a liquid using backpack, broadcast or aerial spray methods and it is not applied directly to vegetation (USDA Forest Service 2006b). Borax is applied to freshly-cut stump surfaces and is typically applied at a rate of one pound per 50 square feet of stump surface. This is equivalent to one pound of borax on 60 twelve-inch stumps (Sporax label, Wilbur-Ellis Company).

Boron is the agent of toxicological concern from Sporax and occurs naturally in soil (USDA Forest Service 2006b). According to the Human Health and Ecological Rick Assessment for Borax Final Report the effects of Sporax to soil microorganisms essential for formation of soil organic matter have not been characterized, and there is a risk of environmental exposures affecting nontarget microorganism (USDA Forest Service 2006b). However, given the atypical application method for Sporax, widespread exposures are not likely, and the risk of effects to soil indicators is minimal. The use of borax will have no significant direct, indirect, and cumulative effects to the soils ability to filter and buffer any chemical compounds.

The use of herbicides for the treatment of invasive plants is planned for the project. Aminocyclopyrachlor will only be applied in the late spring to early summer to maximize the days for the chemicals to degrade as well as minimize leaching and runoff potential. Aminocyclopyrachlor slowly degrades by aerobic microbial metabolism with half-lives ranging from 114-433 days in soils and 29-168 days in water.

Aminopyralid is quite soluble, and its persistence in soil can vary depending on soil type and other environmental conditions. Its half-life in water can range from 0.6 to 990 days and 20 to 60 days in soil with minimal leaching potential below 15 to 30 cm soil depth. Although aminopyralid does not bind readily in soil, it dissipates rapidly in some common soil conditions. No known metabolites of aminopyralid have been identified (SERA, 2007). The projected maximum concentrations of aminopyralid under the proposed application rate would be far below potentially toxic levels on soil micro-organisms. A 2007 study by McMurray showed modest increases in nitrate and total mineral nitrogen concentrations in soil directly following application but no statistically significant effects were noted thereafter (McMurray, 2002). The information on soil-micro-organisms is limited and consists only of a no-observed-effect concentration (NOEC) value for earthworms reported as 5,000 ppm (mg a.e./kg soil). The proposed maximum application rate of 0.1 lbs a.e./acre corresponds to a concentration of about 0.05 ppm and "indicates inconsequential risks to earthworms" (SERA, 2007). Consequently, this information does not provide any basis for asserting that adverse effects on soil-micro-organisms are plausible.

Chlorsulfuron is susceptible to being highly mobile in the environment depending upon soil type. Mobility also usually increases with increasing soil pH and decreasing organic matter. It will move in any direction in the soil profile depending upon water flow. However, it is not expected to cause ground water contamination problems due to its relatively rapid degradation in plants and soils, low use rates and low toxicity.

Clopyralid is relatively persistent in soil, water, and vegetation. It is degraded almost entirely by soil microbes and is not susceptible to photo or chemical degradation. Once clopyralid is applied to soils, it rapidly disassociates (Shang and Arshad 1998), becoming extremely soluble in water, and does not bind strongly with soil particles. Lack of adsorption means that clopyralid has the potential to be mobile and could contaminate ground and surface water via leaching and surface and sub-surface water flows (Tu et al. 2001).

Fluazifop-p-butyl is rapidly hydrolyzed to fluazifop acid in vegetation, soils, and water. In soils and water, both the ester and acid forms are metabolized by soil or sediment microbes, and broken-down to herbicidally inactive compounds. The average soil half-life of the ester form is one to two weeks. Fluazifop-p-butylbinds readily with soil particles, limiting leaching and soil runoff (Tu et al. 2001).

Glyphosate binds readily with soil particles, which limits its movement in the environment (Tu et al. 2001). Therefore, has little potential for leaching or runoff due to its very high adsorption to soils. Glyphosate rapidly and tightly binds to soil. There is little potential for leaching or runoff due to its very high adsorption to soil. As a result, glyphosate becomes inactive as an herbicide upon contact with the soil. Glyphosate is degraded via microbial activity. It has a half-life of 47 days (NPIC 2010).

Imazapyr is weakly bound to soil, adsorption increase as organic matter and clay content increase. Imazaypyr is moderately persistent in soil, but not prone to leaching. In tests in forest soils it did not leach or runoff. The half-life of imazapyr ranges from 25 to 145 days. Microbial degradation is the primary means of dissipation (SERA 2011b).

Triclopyr was reported to have a field half-life of 40 to 46 days in soil, a water solubility rating that ranges from 440 to 8,220 mg/L, and an intermediate to minimal leaching potential. Triclopyr appears to variably persist in soil, with minimal mobility and minimal leaching evident in field studies. Triclopyr is adsorbed primarily to organic matter particles in soil. The organic matter content is the primary factor in the degree of soil adsorption and is not characterized as strong (SERA, 2011). Toxicity data on soil-micro-organisms is limited with triclopyr. The projected maximum concentrations under the proposed application rates would be far below potentially toxic levels, therefore the potential for substantial effects on soil-micro-organisms appear to be low (SERA 2011).

The degree to which soil cover decreases as a result of chemical application is hard to predict. However, design features are in place to mitigate any significant soil cover loss (see Management Requirements Table). The level of soil cover is a proxy for the level of organic material that can absorb applied herbicides. Thus, the soil cover works to lessen herbicide runoff and adsorption for decomposition by soil microbes – the main fate for herbicides (Bollag and Liu 1990).

Most of the proposed herbicides decay primarily by soil microbes. Soil microbial activity increases with temperature such as during the summer months. The application of herbicides may occur in the spring time to be more effective in eradicating or controlling the targeted invasive plants. Overall, the proposed herbicides and application rates would be low enough to facilitate decay by soil microbes (SERA 2004a, 2004b, 2007, 2011a, 2011b, 2011c, 2012, 2014). The proposed herbicide usage would have a low risk for soils since the bulk of treatments will occur in the old quarry site where soils are unproductive and soil communities are uniform. The potential for adverse effects of herbicide residues in soil would be minimized or eliminated by incorporating the project design features (Management Requirements Table) and applying BMPs. Project design features include applying herbicides following strict protocols, spill contingency plans, proper disposal of containers and cleaning equipment, and timeframes when to apply or not apply herbicides. No significant direct and indirect effects are expected with the use of herbicides to treat invasive plants as discussed above.

Due to the application rates and project design features, direct and indirect effects would be minimal or negligible. Consequently, there would be very little risk of any cumulative effects to soils at the project site.

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